

X. PHYSICAL OPTICS OF INVERTEBRATE EYES*

Academic and Research Staff

Prof. G. D. Bernard
Dr. W. H. Miller

Graduate Students

J. L. Allen
F. Beltran-Barragan

A. OPTICS OF THE TOBACCO HORNWORM MOTH

We have made two apparently closely related observations regarding the structure and functioning of the cornea and crystalline cone portion of the optics of the compound eye of the Tobacco Hornworm Moth. (These components presumably form the focusing elements of the optical tract.)

First, we have observed, as shown in Fig. X-1, that the cone and the cornea appear

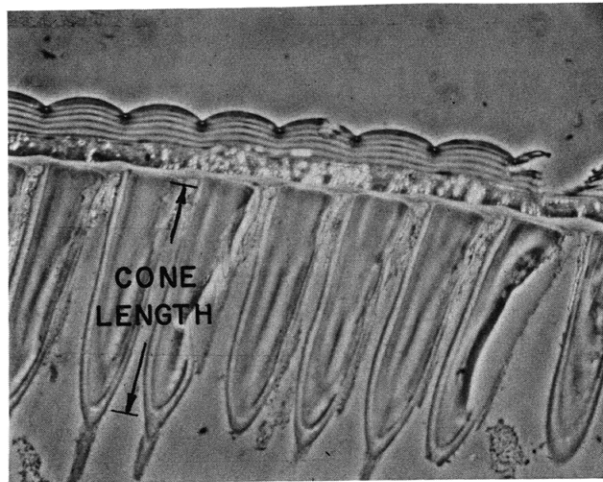


Fig. X-1. Thin ($\sim 2 \mu$), unstained normal section of Hornworm Moth eye as observed by using Zernike phase contrast. Magnification 350X.

structured when observed by phase contrast in the light microscope, thereby suggesting a varying index of refraction (n) with position. The sections show shadowing that is suggestive of a series of thin convex-concave lenses whose radii of curvature increase monotonically as one penetrates into the eye. The outer "lens" has the curvature of the front surface of the cornea; the innermost appears quite flat.

*This work is supported by the Joint Services Electronics Programs (U.S. Army, U.S. Navy and U.S. Air Force) under Contract DA 28-043-AMC-02536(E).

(X. PHYSICAL OPTICS OF INVERTEBRATE EYES)

Second, we have found that if one ray traces through the cornea and cone under the assumption of a uniform \underline{n} of 1.5 (the nominal value for chitinous cuticle), the focal point falls approximately half way through the cone — a rather unlikely focal point for efficient use of the remainder of the optical tract. The discrepancy seems too large to be attributable simply to use of an inexact value of \underline{n} .

These two observations suggest that the cornea and cone gradations substantially alter the focal length from that predicted by the simple constant- \underline{n} model. We have confirmed by experiment that the focal length is different. We observed the focussing action of a cleaned-out cornea through the microscope and found that the corneal lens alone has a focal length (measured from its outer surface) of approximately 110 μ , contrasted with a predicted focal length for a constant index model of the corneal lens alone (with the cone removed) of approximately 56 μ . It remains to be confirmed that the observed structure is a change in index of refraction and that such a variation can account for the observed focussing action. We shall make quantitative measurements on \underline{n} as a function of position, using interference microscopy to verify our hypothesis that the change in \underline{n} is the explanation for the observed long focal length.

J. L. Allen